Response of Nontarget Species to Underground Strychnine Baiting for Pocket Gopher in Southwest Oregon

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ABSTRACT: *Pocket gophers (*Thomomys *spp.) impede reforestation efforts in the Pacific Northwest and strychnine baiting is used to reduce their populations. We conducted a capture and release program in southern Oregon to determine whether strychnine baiting negatively impacted nontarget small mammal species. Two nontarget species dominated the program: golden mantled ground squirrels (*Spermophilus lateralis*) and yellow pine chipmunks (*Tamias amoenus*). There was a short-term decline in ground squirrel populations after baiting, but yellow pine chipmunk populations were not adversely affected. We conclude that underground baiting with 0.5% strychnine treated grain is unlikely to cause long-term adverse effects on nontarget wildlife species in southwest Oregon. West. J. Appl. For. 17(1):9–13.*

Key Words: Hazards, nontarget species, pocket gopher, strychnine bait.

Pocket gophers (*Thomomys* spp.) are an impediment to reforestation efforts in the Pacific Northwest (Capp 1976, Crouch 1986, Marsh and Steele 1992). Pocket gophers commonly prune roots of seedlings and girdle or clip seedling stems. Stems are generally clipped at or near ground level. Small seedlings (< 1.5 cm in diameter) are the most vulnerable, but pocket gophers also prune roots and girdle stems of larger trees. A variety of tree species are vulnerable to damage, including ponderosa pine (*Pinus ponderosa*), lodgepole pine (*P. contorta*), Jeffery pine (*P. jeffreyi*), red firs (*Abies* spp.), Douglas-fir (*Pseudotsuga menziesii*) and Englemann spruce (*Picea engelmannii*) (Canutt 1970, Barnes 1973). Annual seedling losses are reported to vary from 5 to 50% (Barnes 1973).

Efforts to establish tree seedlings on sites infested with pocket gophers can be futile unless protective measures are implemented. Management practices to reduce damage inflicted by pocket gopher include habitat manipulation, such as herbicide treatments (Keith et al. 1959, Hansen and Ward 1966); silvicultural practices, such as planting immediately after logging, minimizing disturbance of a site after logging, or selective cutting (Crouch 1986, Marsh and Steele 1992); physical exclusion devices (Hooven 1971, Anthony et al. 1978); trapping (Crouch and Frank 1979, Smeltz 1992); fumigation (Sullius and Sullivan 1993); repellents (Sullivan 1987, Sullivan et al. 1990); and rodenticides, such as strychnine bait (Marsh and Howard 1978). Except for strychnine, these methods are generally difficult and slow to implement, as well as expensive, and are often ineffective at reducing damage (Anthony et al. 1978, Marsh and Steele 1992). Accordingly, strychnine baiting is widely used to reduce pocket gopher populations in areas targeted for reforestation (Chase et al. 1982, Teipner et al. 1983, Marsh 1992).

Strychnine bait is applied below ground in active burrow systems to maximize its efficacy to reduce pocket gophers and to minimize negative impacts on nontarget species. Some small mammal species, however, use pocket gopher burrows (Howard and Childs 1959). Burrow use and the consequent exposure to bait is affected by several factors including species, habitat type, and season (Fagerstone et al. 1980). Thus, the impact of strychnine baiting on nontarget species can be expected to vary among sites (Fagerstone et al. 1980). Strychnine baiting in eastern Idaho did not affect small mammal populations (Fagerstone et al. 1980). However,

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golden mantled ground squirrel populations declined immediately after strychnine baiting in eastern Oregon (Anthony et al. 1984). Nontarget small mammal populations, primarily western harvest mice (*Reithrodontomys megalotis*), also declined on treated plots in Minnesota (Hegdal and Gatz 1976). A significant secondary hazard to avian or mammalian predators was not detected during any of these studies (Hegdal and Gatz, 1976, Fagerstone et al. 1980, Anthony et al. 1984).

We conducted a capture and release program before and after baiting to determine whether small mammal populations were negatively impacted by strychnine baiting to reduce pocket gophers on reforestation sites in southwest Oregon.

Methods

The study was conducted on the Rogue River National Forest in Klamath County approximately 30 km east of Ashland, Oregon. The experiment was replicated on two reforestation units targeted for pocket gopher population reduction. Two experimental plots were established on each unit. One of these plots was randomly selected for strychnine application, and the other plot served as an untreated control to monitor temporal effects not related to strychnine baiting. Each plot was 2.8 ha (140 200 m) with a grid system composed of 70 quadrants (20 20 m) established across it to ease mapping of captured animals. A minimum of 200 m separated all study plots. Unit elevations ranged from 1500 to 1600 m.

Vegetation and woody debris were evaluated on each experimental plot to ensure similarity among sites. The distribution and abundance of small mammals (Rosenzweig and Vinakur 1969, Dueser and Shugart 1978, Maser et al. 1979) and their capture success (Hayes and Cross 1987) can be greatly affected by these habitat characteristics. These components were assessed on 6 randomly selected quadrants (20 20 m) from the 70 quadrant grid established across each experimental plot. Vegetation was measured on 20 plots randomly placed within in each quadrant (0.25 m^2) by the dry weight rank method ('t Mannetje and Haydock 1963, Jones and Hargreaves 1979). The amount and characteristic of down wood were measured as described by Maser et al. (1979). Briefly, the volume of logs and stumps is assigned to a decomposition class: (1) log intact; (2) log intact to partially soft; (3) bark starting to loosen; (4) log soft and starting to decompose; and (5) log very soft and powdery.

Steam-rolled oats with 0.5% strychnine were applied by contractors according to USDA Forest Service specifications during late August and September 1995. This operation consisted of applying bait twice, first on August 28 (0.45 kg/ha) and then again on September 4 (0.05 kg/ha). Open hole monitoring by the contractor indicated that the initial two baitings failed to achieve the 80% decline in pocket gopher activity required by the Forest Service. Therefore, a third baiting was conducted on September 30 (0.4 kg/ha).

Fresh mound counts indicated similar pocket gopher activity prior to baiting on all experimental plots. An effort was made to capture all pocket gophers on one of the baited experimental plots prior to treatment. Forty-five pocket gophers were captured on this plot. Thirty-one of these animals were fitted with radio collars and released at the site of capture. The other 14 pocket gophers were marked with an AVID (American Veterinarian Identification Device) microchip and released at the site of capture. Pocket gophers with radio collars were located at least twice a week until 2 wk post baiting. Locations were marked with flags, and animals that failed to move were considered dead. Animal fate was confirmed when radio collars were retrieved at the conclusion of the study.

A capture and release program was used to monitor the occurrence of small mammals. Trapping was conducted once prior to baiting, then three times at 2 wk intervals after treatment, with a followup trapping period during May 1996, shortly after snow melt, and then twice the next fall (1996) at 2 wk intervals that reflected the pretreatment and the first posttreatment trapping periods. Trapping was conducted on five consecutive days each time. One Sherman live-trap (23 8 9 cm) and one Sprague live-trap (25 9 9 cm) were set approximately 1 m apart at the center of each of the 70 quadrants on all study areas. Traps were baited with a mixture of peanut butter, rolled oats, raisins, and fried bacon. On first capture, animals were weighed, sexed, and inserted with an AVID microchip for identification. On subsequent captures, the location and microchip number were recorded. Animals then were released at the site of capture.

Location of any animal carcass encountered during the study was recorded, and the animal was examined to determine whether it had been previously marked with a microchip. When possible, microchip numbers were recorded; if a microchip was not present, then the species of the animal was recorded.

Nontarget populations were estimated with the CAPTURE software package (Otis et al. 1978). Sampling periods were relatively short (5 days), therefore the closed population model was selected to estimate abundance of nontarget populations (Otis et al. 1978, White et al. 1982, Pollock et al. 1990). The CAPTURE program considers eight models: equal catchability (M_o), heterogeneity in individual response (M_h), trap response, (M_b), time response (M_t), and combinations of the latter three (M_{bh}, M_{th}, M_{tb}, M_{tbh}). The procedure is based on goodness of fit tests, and the program selects the most appropriate model.

A two-factor repeated measures ANOVA was used to assess differences among population estimates for each species. The independent factors were treatment (two levels) and trapping dates (seven levels). Least significant difference (LSD) tests were used to isolate significant differences among means subsequent to the omnibus procedure ($P < 0.05$).

Results

Students' *t*-test comparisons indicated that vegetation and woody debris were similar ($P < 0.05$) across the four experimental plots. Therefore, small mammal populations were likely to be similar across study sites and plots within a site.

The mean pocket gopher density within the four experimental plots was approximately 16 animals per ha. The mean mortality of the pocket gophers with radio collars was 85% after the first two baitings (August 28 and September 4, 1995) and 92% after the third strychnine application (September 30, 1995). Mound counts the next spring (May 1996) were considerably lower on baited plots but were similar on all plots the following fall (1996). Recovery of radio-collared carcasses indicated that all but one pocket gopher had died below ground either in a nest or in a burrow. None of the carcasses appeared to have been eaten by predators. Twenty-six radio-collared pocket gophers were recovered; the five radio-collared pocket gophers that were not recovered lost their collars prior to baiting. A weasel was captured in a pocket gopher trap, along with a pocket gopher, prior to baiting, but whether weasels preyed on the missing collared pocket gophers is unknown.

Nontarget Activity

Ten nontarget species were captured and released during the study. The golden mantled ground squirrel (*Spermophilis lateralis*) and yellow pine chipmunk (*Tamias amoenus*), however, were the only species present in sufficient numbers to adequately assess population changes. Other species encountered much less frequently were Townsend chipmunk (*Eutamias townsendii*), Siskiyou chipmunk (*Eutamias siskiyou*), Oregon vole (*Microtus oregoni*), longtailed weasel (*Mustela frenata*), bushytail woodrat (*Neotoma cinera*), deer mouse (*Peromyscus maniculatus*), mole (*Scalopus* spp.), and Douglas squirrel (*Tamiasciurus douglasii*).

Equal catchability (M_0) and heterogeneity in individual response (M_h) were selected by CAPTURE as the most appropriate models of ground squirrel and chipmunk populations, respectively. These models indicate that ground squirrel individuals were equally likely to be captured, and the probability of capture within each trapping period was independent of the other trapping periods, whereas the probability of chipmunk capture was influenced by the individual's sex and age.

Ground squirrel numbers declined immediately after baiting on treated plots relative to control plots (Figure 1). At 2 and 4 wk postbaiting there was a significant decline ($P < 0.05$) in populations. Few animals were active on either of the plots 6 wk after baiting, probably as a result of animals hibernating. Populations were similar ($P > 0.05$) to pretreatment levels the next spring and fall.

Chipmunk populations did not appear to be negatively affected by the strychnine treatment (Figure 2). Populations remained similar ($P > 0.05$) on treated and untreated plots throughout the fall after baiting. The next spring chipmunk populations were higher ($P < 0.05$) on the treated plots than they were on the control plots.

Several ground squirrel (15) and chipmunk (7) carcasses were found above ground. The majority of these carcasses were discovered after the third baiting. A few animals had strychnine bait in their cheek pouches. Carcasses were consumed by insects (e.g., wasps, ants) and were virtually gone within 48 hr.

Discussion

Strychnine baiting effectively reduced pocket gopher populations in our study. Mortality of radio-tagged pocket gophers was 85% after the first two baiting operations and 92% after the third application. These results are consistent with other studies reporting strychnine baiting to be an effective means to at least temporarily reduce pocket gopher populations (Barnes 1974, Birch 1978, Crouch and Frank 1979, Barnes et al. 1985, Campbell et al. 1992, Marsh 1992). Populations of pocket gopher, like other rodents, are dynamic, and lost animals are quickly replaced. Activity levels monitored in our study indicated that pocket gopher populations were similar on treated and untreated plots within a year of treatment. This rapid rebound following efforts to reduce pocket gopher populations also is consistent with other studies (Campbell et al. 1992, Marsh 1992).

Negative effects on nontarget species are a concern of any person implementing a baiting program. Though strychnine bait is applied below ground to reduce hazards, there is a potential for nontarget animals to encounter the bait. Some rodent species have been found in pocket gopher burrow systems (Howard and Childs 1959, Vaughan 1961). Which nontarget species are present can be expected to vary among sites due to changes in habitat (Fagerstone et al., 1980). The occurrence and abundance of species are closely associated with habitat components (Dueser and Shugart 1979, Maser et al. 1979, Hayes and Cross 1987).

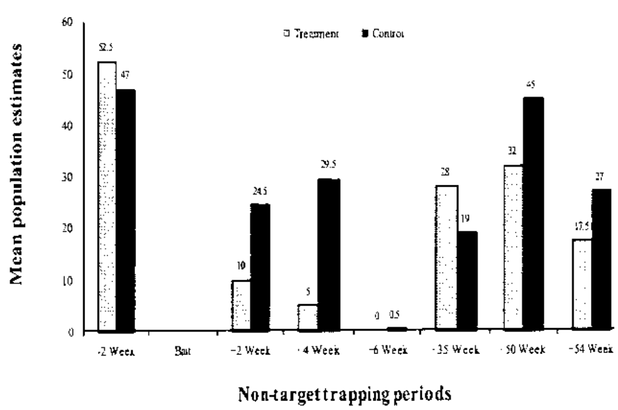

Figure 1. Mean population estimates for golden mantled ground squirrel on control (CON) and treated (TRT) plots 2 wk before treating with strychnine bait to reduce pocket gopher populations in southwest Oregon and at 2, 4, 6, 35, 50, and 54 wk after baiting.

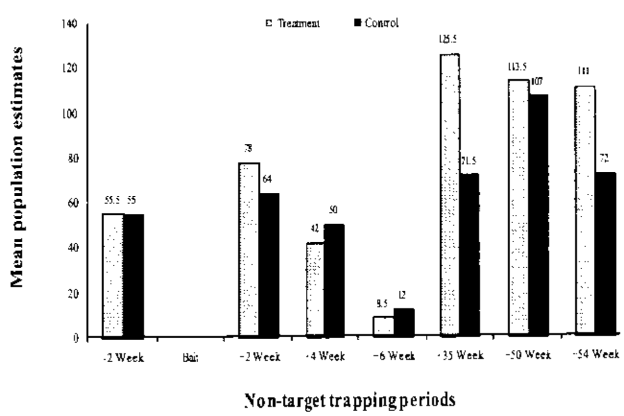

Figure 2. Mean population estimates for yellow pine chipmunk on control (CON) and treated (TRT) plots 2 wk before treating with strychnine bait to reduce pocket gopher populations in southwest Oregon and at 2, 4, 6, 35, 50, and 54 wk after baiting.

Ten nontarget mammal species were captured during the course of our study in southwest Oregon. Only two of these species had sufficient populations to assess changes after strychnine baiting. Fortunately, pretreatment population levels of these species were similar across all sites, most likely because all the selected sites contained similar vegetation and amounts of down wood.

Population responses of golden mantled ground squirrel and yellow pine chipmunk postbaiting in this study were similar to results reported in other studies. Anthony and others (1984) reported a 72% decline in golden mantled ground squirrels shortly after strychnine baiting, with a population rebound the following spring. Yellow pine chipmunk populations in our study were not negatively impacted by strychnine baiting. Fagerstone et al. (1980) also failed to detect lower populations of chipmunks post strychnine baiting. In contrast, our study indicated a slight, but significant, increase in chipmunks on treated plots relative to control plots the following spring. This increase may reflect an invasion of chipmunks to fill a void created by the decrease in ground squirrels. Conceivably, ground squirrels and chipmunks compete for resources since both animals were attracted to and captured in the same traps.

Although strychnine baiting did not cause long-term population changes, obviously some individual animals were affected. Ground squirrel numbers declined immediately post baiting, and some ground squirrel and chipmunk carcasses were recovered above ground. Strychnine bait was detected in the cheek pouches of some of the ground squirrels demonstrating that they had had access to underground strychnine baits. Anthony et al. (1984) reported the majority of the ground squirrel carcasses (19 of 26) recovered in their study were located above ground. Chemical assays revealed that strychnine poisoning induced death in 25 of these animals (Anthony et al. 1984). Fagerstone et al. (1980) also reported individual nontarget loss attributed to strychnine poisoning. Three of the 30 chipmunks fitted with radio collars for the Fagerstone et al (1980) study died, and strychnine residues were detected in the body and gastrointestinal tract of two of these animals.

Few predators or scavengers were encountered during the study; therefore, it was impossible to assess secondary hazards. The presence of animals that succumbed to strychnine bait, however, indicated some potential for exposure to secondary poisoning. The likeliness for exposure was reduced because of the rapid disappearance of carcasses, due largely to insect activity. These results were consistent with other studies that reported insects being major contributors to carcass degradation (Sullivan 1988, Witmer et al. 1995). Anthony et al. (1984) assessed the fate of mink (*Mustela vison*) and two raptors, great horned owl (*Bubo virginianus*) and red-tailed hawk (*Buteo jamaicensis*), fed strychnine contaminated golden mantled ground squirrels. They concluded that secondary poisoning of mustelids was possible provided the weasels ingested the stomach contents along with the carcass. They also concluded that it was unlikely for raptors to be poisoned if they preyed on golden mantled ground squirrels killed with 0.5% strychnine bait. Fagerstone et al. (1980) found no evidence of secondary poisoning of any species in their study. Another study that monitored the behavior of avian and mammalian predators on fields treated with strychnine bait to control pocket gophers also failed to detect secondary hazards (Hegdal and Gatz 1976).

Management Implications

Strychnine baiting can be an effective, albeit short-term, means to reduce pocket gopher populations. Our findings were consistent with those of other studies that underground baiting of forest pocket gophers with 0.5% strychnine-treated grain is unlikely to induce long-term adverse effects on nontarget wildlife species (Hegdal and Gatz 1976, Fagerstone et al. 1980, Anthony et al. 1984). Nevertheless, precautions can be taken to further minimize potential risk (Anthony et al. 1984). Product labels and application instructions must be followed carefully throughout the operation. Anthony et al. (1984) suggested prepoisoning surveys for sensitive species, postbaiting carcass searches and removals, use of grain baits rather than fresh baits, late baiting, and nontoxic alternatives. Species such as golden mantled ground squirrels have a relatively early hibernation. Ground squirrel activity in our study had virtually ceased by the late monitoring periods. Thus, a window of opportunity may have existed to treat pocket gophers with minimal exposure to ground squirrels. The obvious concern with this approach would be the reduced timeframe for bait application and the unpredictable nature of weather. Early snows could render late treatments impossible in some years. Management plans also need to consider the use of nontoxic alternatives, such as trapping, barriers, repellents, cultural methods (i.e., planting trees undesirable to pocket gophers), and habitat manipulation (Case and Jasch 1994). Unfortunately, many of these techniques have been demonstrated to be either cost prohibitive or ineffective. Finally, aversive agents could be added to bait to render the baits less desirable to nontarget species or in some instances aversive conditioning could be used to train some nontarget individuals to subsequently avoid baits (El Hani et al. 1998). Such modification of bait ingredients, however, may require pesticide label changes, and additional data might be required by regulatory agencies.

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